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Cost of intensive care in a Norwegian University hospital 1997–1999

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Abstract

Aim The present study was performed in order to document costs of intensive care in a Norwegian university hospital and to perform an average cost-effectiveness study using the expected remaining life-years in survivors after 18 months.

Materials and methods Patients admitted to the general intensive care unit (ICU) at Haukeland University Hospital from 1997 to 1999 were followed up to 18 months post ICU using data from the Norwegian Peoples' registry. Our ICU patients have a further mortality equal to the average population in Norway from that time. By creating an age-matched and sex-matched sample of the general Norwegian population equal to survivors 18 months after ICU treatment, we could find the expected further survival time for each ICU survivor. Direct and indirect ICU expenses in the study period were retrieved using a 'top-down' method. Outcome assessment was performed using the total ICU expenses in the period divided by the sum of the life expectancy (years) in survivors after 18 months.

Results The total ICU costs (converted to 2001 values) were €16,697,415, excluding the costs of radiology and the use of operating theatres, which were both impossible to retrieve. A total of 1051 patients were treated, of whom 60.9% survived up to 18 months. Further total life expectancies were 24,428 years. The average costs of an ICU day and stay per patient were €2601 and €14,223, respectively, and the average cost per year of survival per patient was €684.

Discussion The absolute costs were found to be higher than recent European ICU studies reporting on the cost of ICU treatment. However, the price of a further life-year in survivors was lower and was comparable with other medical treatment.

Keywords intensive care/economics, life expectancy, outcome assessment (health care)

Introduction

The increasing cost of modern medicine is a challenge. Health authorities and government of care try to reduce costs, or at least to reduce the increases in costs of health care. The patients (consumers) demand an increasing amount and range of treatments, and in between is the health care deliverer (physician) trying to combine such seemingly opposite inputs.

It is generally claimed that intensive care is very expensive. In the USA the sum of resources used for intensive care is estimated to be 1% of the Gross National Product [1], while it is probably considerably less in European countries [2]. On the other hand, intensive care in underdeveloped countries often does not exist beyond the recovery room.

In a provoking review about cost studies in the intensive care unit (ICU), Gyldmark in 1995 found methodologies for costing ICU therapy to be flawed and to be failing in providing correct answers [3]. Since that report, new studies have addressed this problem and have developed better methods for costing of individual ICUs [2,4,5].

There are still few published reports on the overall cost of intensive care, and we were not able to find any data from Scandinavia for the past 10 years. The primary aim of the present study was to document ICU costs in a Norwegian university hospital from 1997 to 1999, and to perform an average cost-effectiveness study using the expected further survival time in survivors 18 months after discharge from the ICU.

Materials and methods

Haukeland University Hospital is a 900-bed tertiary referral hospital for approximately one million inhabitants in western Norway, with approximately 65,000 admissions per year. There are four ICUs in the hospital: one neonatal ICU, one cardiac ICU, one burns ICU, and one general (mixed) ICU serving all hospital departments. This general ICU has 10 beds, but is usually staffed for up to eight patients due to a shortage of ICU nurses. The general ICU is by far the largest ICU in the hospital regarding the number of critically ill adult patients treated annually, and the present study is constrained to patients admitted to this unit.

This is a retrospective study of prospective collected data from 1 January 1997 to 31 December 1999.

Economic evaluation

The direct and indirect costs concerning the general ICU were retrieved by a 'top-down' method [4]. Direct costs were defined as all costs directly generated in our ICU (cost reflected in the ICU account). This included wages for all staff working in the ICU only (full-time or part-time ICU nurses and physicians), all consumables including drugs and infusions, the cost of capital equipment and the cost of estates (ICU area in the hospital). The costs of wages and consumables were taken directly from the ICU accounts from 1997–1999.

The value of all capital equipment was retrieved from databases at the Department of Biomedical Engineering. The average life span and annual costs of for maintenance and repair were estimated to be 10 years and 5% of the total value, respectively.

The cost of estates includes cleaning, electricity, information technology services, laundry and uniforms, administration, security and internal transport. In our hospital this sum is calculated by the hospital administration as a fixed sum per year per square meter area.

Indirect costs were defined as costs inflicted by other hospital departments during the treatment of patients in the ICU. This includes procedures such as laboratory analysis, blood-bank services, X-ray services, physiotherapy, visits by consultants outside the ICU and the use of operating theatres. Each department was asked to give a report of their costs or to give their cost estimate for their service to ICU patients during the studied 3 years.

All costs were originally generated in Norwegian Kroner. These are corrected for the increase in the consumer price index of Norway between the actual year and 2001 (11.1% from 1997, 8.7% from 1998 and 6.3% from 1999). This sum and the derived values are all presented in Euros using a conversion from Norwegian Kroner calculated as 1 € = 7.45 Nkr (June 2002).

Patients

The number of patients and ICU stays in the period 1997–1999 were retrieved from our ICU database (REGINA) [6]. The simplified acute physiology score, version II has routinely been used for severity scoring in patients older than 16 years [7], and the nine equivalent of nursing manpower use score [8] has been used for resource utilisation in all patients. At the time of admission, patients were categorised into one of eight groups of main indications for the ICU admission (Table 1). Appropriate International Classification of Diseases, version 10 codes generated from admission to the ICU through to discharge from the ICU were also collected. Patients with one or more codes for severe sepsis were, in addition, analysed separately. Survival for all patients up to 18 months post ICU discharge was investigated using data from the Peoples' Registry of Norway, and times of death were registered. Kaplan–Meier survival analysis was performed.

We have previously documented that our ICU survivors reach the expected further survival of the normal Norwegian population between 1 and 2 years after ICU discharge [9]. Available life tables published by Statistics Norway [10] were used to create an age-matched and sex-matched sample of the Norwegian population equal to our ICU survivors after 18 months. In this way, the expected survival time for each ICU survivor from 18 months onward was found.

Cost-effectiveness study

Our cost-effectiveness study is best described as an average cost-effectiveness ratio since we do not compare intensive care with an alternative treatment [11]. The present study does not comply with all the recommendations for reporting cost-effectiveness in medicine [12] since we do not have a proper control group for our intensive care population, which is necessary for calculating the incremental cost-effectiveness ratio. Furthermore, we have only calculated costs gener-

ated while the patients were in the ICU. We have not included costs inflicted during the rest of the hospital stay or occurring after hospital discharge. Our cost calculation is therefore less than the total costs generated by these patients. Patients are usually admitted to the ICU because of vital organ failure secondary to disease or injury. In the further treatment of the ICU survivors, it is difficult to extract the costs inflicted by the ICU stay as opposed to costs from the original disease or injury. Since our aim was to study costs and the outcome of our critically ill ICU patients, a control group would have to be treated outside the ICU (in our hospital on the ordinary ward), without the use of ventilators, invasive monitoring, and so on.

In the present analysis we used the expected lifetime of patients surviving longer than 18 months as the efficacy parameter, and the costs as all direct and indirect ICU expenditure in the period 1997–1999. Subgroup analyses were performed regarding the eight different ICU groups. The society perspective was taken in our analysis.

In a sensitivity analysis, we included two relevant clinical changes: an increase in the standardised mortality ratio from 0.8 to 1.0 and 1.2, and a reduction of the standardised mortality ratio to 0.7. The two increased values would increase the number of hospital nonsurvivors and hence reduce the number of life-years gained. The latter, reduced value would have the opposite effect. We also varied our expenses with a total increase in ICU costs of 25% (likely to happen in the next 3–4 years) and a separate analysis of a 100% increase in drug expenses. Finally, we performed a sensitivity analysis of introducing a new treatment (estimated to cost €10,000 per treatment) in patients with severe sepsis, calculating an absolute increase in survival of 6.1% in these patients [13].

Results

Patient data

In the study period, 1051 patients had a total of 1174 stays and 6400 days (counted as hours per 24 hours) in our ICU. The mean simplified acute physiology score, version II was 44.2 and the mean nine equivalent of nursing manpower score per day was 36.2. A total of 109 patients were found to have severe sepsis.

The following diagnostic investigations were performed by the Department of Radiology during 1997–1999: 653 computed tomography scans, 54 magnetic resonance imaging scans and 57 angiographies, in addition to 2300 chest X-rays taken in the ICU. A total of 313 operations were performed in the operating theatre. The distribution of patients in categories at admission and in survivors after 18 months is presented in Table 1.

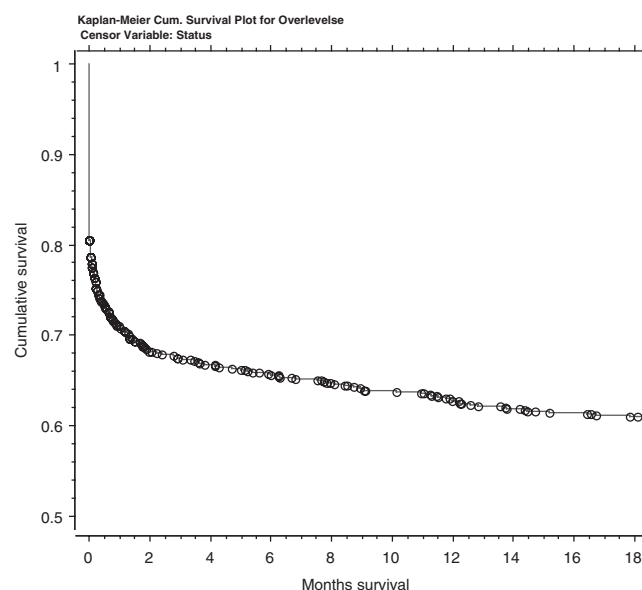
A total of 640 patients (60.9%) survived 18 months (Fig. 1) Patient characteristics for survivors and nonsurvivors are presented in Table 2.

Table 1

The eight main indications for intensive care unit treatment and the number of patients in each group at the start and after 18 months

| | Start (n=1051) | 18 months (n=640) |
|------------------------------|-------------------|----------------------|
| Acute cardiovascular failure | 155 | 73 |
| Acute respiratory failure | 266 | 161 |
| Acute renal failure | 14 | 11 |
| Multitrauma | 120 | 98 |
| Postoperative | 47 | 32 |
| Central nervous system | 278 | 165 |
| Gastrointestinal | 123 | 63 |
| Other reason | 48 | 37 |

Figure 1



Kaplan–Meier survival curve.

The 640 patients surviving 18 months after ICU discharge could expect to live a total of 24,428 years thereafter. This number of years is used in the cost-effectiveness analysis.

ICU costs

The total direct and indirect ICU costs from 1997 to 1999 were €16,697,415, giving an average price per ICU day of €2601 and an average price per ICU stay of €14,223. It was not possible to reveal the cost of the radiology service in ICU patients in the studied period, nor the costs of operative procedures performed in the operating room during the ICU

Table 2**Patient characteristics for survivors and nonsurvivors**

| Group | Dead at less than 18 months | Alive after 18 months or more | All patients |
|------------------------------|-----------------------------|-------------------------------|--------------|
| Patients | 411 | 640 | 1051 |
| ICU stay | 500 | 674 | 1174 |
| Mean ICU stay (days) (SD) | 5.9 (10.9) | 5.1 (8.5) | 5.5 (9.6) |
| Mean age (years) | 59.1 | 42.8 | 49.2 |
| SAPS II (mean) | 54.8 | 36.1 | 44.2 |
| Mean ventilator days (SD) | 5.5 (10.5) | 5.0 (8.0) | 5.3 (9.3) |
| Estimated mortality | – | – | 36.9% |
| Dead in the ICU | – | – | 198 |
| Dead in hospital (%) | – | – | 308 (29.3%) |
| Standardised mortality ratio | – | – | 0.79 |

ICU, intensive care unit; SAPS II, simplified acute physiology score, version II; SD, standard deviation.

stay. These two indirect costs are missing in our results. Patients with severe sepsis cost, on average, €35,906 per stay and €2671 per day.

Direct costs were 88.7% and indirect costs were 11.3% of the total costs in the period. The wages for ICU nurses was by far the single largest of all costs at €8,779,330, followed by physician wages of €2,004,275 (Fig. 2).

Average cost-effectiveness results

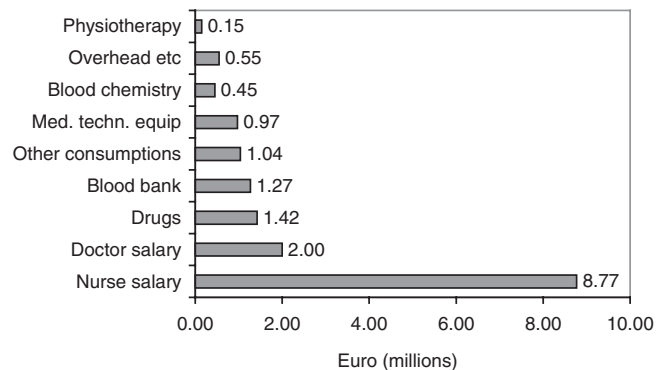
The cost of each expected life-year in the survivors after 18 months was, on average, €684, with a variation from €249 in postoperative patients to €1603 in patients treated for gastrointestinal problems (Table 3). Patients with severe sepsis gained a total of 2183 life-years with an average cost per life-year of €1859. The cost of an expected life-year in ICU survivors aged 70 years or older was €2785 ($n=98$), that in survivors aged between 18 and 70 years was €751 ($n=417$) and the cost of an expected life-year in those younger than 18 years was €363 ($n=125$).

Results from the sensitivity analysis performed (expressed as Euros per life-year) are presented in Table 4.

Discussion

In the present study we have found the average costs in a Norwegian ICU, from 1997 to 1999, to be €2601 per day and €14,223 per stay. The average cost of an expected life-year in survivors after 18 months was, on average, €684.

The absolute cost of running our ICU is somewhat higher than that recently reported in European studies. Edbrooke and coworkers reported the average cost per day and per

Figure 2

Contribution (%) of the different direct and indirect costs in the intensive care unit 1997–1999 (total expenses €16,697,415).

stay in a multicentre UK study from 1996 to 1997 to be €1406 (range €1288–1809) and €6275 (range €5412–8003), respectively [14]. The daily treatment cost in a German medical ICU in 1997–1998 was found to be €1336 [15], and an average cost of €9771 per ICU stay in a medical ICU was found in France in 1996–1997 [5]. On the other hand, in a recently published study from Canada (1996–1999) the average cost of intensive care (converted to 2001 values) for patients with sepsis was US\$3208 (€3583) per day [16]. This is more expensive than the cost of our patients with severe sepsis, which was €2671 (US\$2392) per day.

There may be several reasons for such differences. One major factor is probably nurse wages, which are high in Norway and other Scandinavian countries. The part of the total costs going to ICU staff wages was found in the UK to be 53.6% and 54.9% in 1994–1995 and 1995–1996, respectively [2], compared with 63% in the present study. In that same study, Edbrooke and coworkers found that the absolute expenses to ICU staff rose by 1.3% in only one year (1994–1995 to 1995–1996). Our study was performed more recently and may therefore reflect a higher cost. In addition, our costs are expressed as 2001 values; if converted to 1996 values, the mean ICU cost per stay in the present study was €2208.

Increased costs in our ICU may also result from the fact that Norwegian health expenditure per capita in 1998 was found to be 61% higher than that in the UK (US\$2467 compared with US\$1532) [17].

As pointed out earlier in the Results, the present study does not include two important costs: radiology, and the use of operating theatres. It was not possible for us, even after several attempts, to retrieve the actual costs of these activities in the hospital. If data from the UK study are valid for us,

Table 3**The number of life-years and its cost in intensive care unit survivors in different groups**

| Intake group | Life-years | € per year |
|------------------------------|------------|---------------|
| Acute cardiovascular failure | 2133 | 1251 |
| Acute respiratory failure | 5935 | 751 |
| Acute renal failure | 535 | 365 |
| Multitrauma | 4238 | 359 |
| Postoperative | 1083 | 249 |
| Central nervous system | 6505 | 547 |
| Gastrointestinal | 2128 | 1603 |
| Other reason | 1781 | 329 |
| Mean | | 684 |
| Median (interquartile range) | | 456 (352–825) |

the cost of radiology is approximately 50–60% of the cost of laboratory services, meaning approximately 1.5% of the total ICU costs in the present study. If we estimate the cost of an operating room to be five times the ICU costs per hour, and the average use of an operating theatre to be 3 hours, this amounts to approximately €500,000 (3.3% of the total ICU costs). From these assumptions we do believe that the costs of radiology services and operating theatres would add a comparatively small amount (<5%) to our results.

The cost of life-years gained in survivors is another way of looking at the cost of intensive care. A traditional cost-effectiveness study in general ICU populations would be hard to perform in most developed countries. To do this one also had to treat a comparable population in need of intensive care with standard care only, without the use of intensive care procedures and observation in an ICU [18]. Such a study could have compared the two groups with regards to total costs and the number of expected life-years in survivors from each group. This difference (incremental cost-effectiveness ratio) could then be taken as the effect of ICU treatment in general. Such studies are hard to perform for obvious reasons, and probably would be regarded as unethical by health personnel as well as patients. This is probably the reason why such a study has not been performed in recent years. Instead, cost-effectiveness studies in the ICU often deal with more defined and less controversial problems. A recent publication of the cost-effectiveness of treating ICU patients with severe sepsis using activated protein C is an example of such studies [16].

In a study from Canada the cost-effectiveness of the ICU was found to be Can\$4350 (€2978) per life-year saved, compared with a group of ICU patients where all active treatment was stopped [19]. In that study, patients were followed until 12 months after ICU discharge. An assumed average further

Table 4**Sensitivity analysis performed, expressed in € per life-year and percent change from average cost**

| Analysis performed | €/life-year | % |
|---|-------------|-----|
| Average cost | 684 | 100 |
| Increasing SMR to 1.0 | 780 | 114 |
| Increasing SMR to 1.2 | 908 | 133 |
| Decreasing SMR to 0.7 | 644 | 94 |
| 25% increase in all intensive care unit costs | 854 | 125 |
| 100% increase in cost of medication | 742 | 108 |
| Introducing a new treatment for severe sepsis | 720 | 105 |

SMR, standardised mortality ratio.

survival of 15 years was used in their calculations. It could be argued against this method that a group of patients whose ICU treatment is withdrawn is a poor control group to an active treatment group. In addition, their estimate of further survival is different from our calculation of individual survival time derived from national statistics in a sex-matched and age-matched sample. We used this calculation since we have previously documented that further survival in our ICU patients beyond 1–2 years is equal to the normal population [20]. Our price per life-year in survivors (€683) was considerably less than that in the Canadian study in spite of a more than twice the average cost per ICU day.

Another way of evaluating the outcome of the ICU in the long term is to use 'quality-adjusted life-years' (QALY). This has been done in subgroups of ICU patients [21] but, to our knowledge, has only been published once regarding a whole ICU population [22]. In that study (from Australia) they found the price per QALY in 150 survivors 3 years after ICU treatment to vary between €178 for asthma and €1390 for pulmonary oedema. This corresponds reasonably well with our variations in cost of a life-year from €249 to €1603. One problem when dealing with QALY is the necessity of obtaining a measure for quality of life (QOL) and comparing this with a 'normal' population. Obviously, many of our patients would probably have reported a reduced QOL after ICU treatment. In patients surviving 13 years after the ICU, we found their average health-related QOL to be reduced but to be less than in another group of ICU patients after 3 years, indicating improvement with time [20]. It is probably difficult to provide one fixed figure for health-related QOL in survivors after ICU treatment.

In a study from the USA, ICU patients receiving mechanical ventilation for acute respiratory failure and acute respiratory distress syndrome between 1989 and 1994 were investigated with regards to outcome and QALY [23]. Of the 963

Key messages

- The average costs of an intensive care unit day and stay in a Norwegian university hospital during the years 1997–1999 were € 2601 and € 14,223, respectively
- Wages for intensive care unit nurses and physicians were 63% of the total intensive care unit costs in the study period
- Of the 1051 patients admitted, 640 (60.9%) survived up to 18 months with a total further expected survival time of 24,428 years
- The average cost of a survival year (all intensive care unit costs in the period divided by the sum of expected survival time) was € 684

patients studied, 48% survived for at least 6 months and 72% rated their QOL as good, very good or excellent. Hamel and coworkers found the cost for QALY to vary from US\$29,000 to US\$110,000 according to different risk groups. The very much higher costs per QALY in that study are mainly a result of adding an estimate of annual further costs for each survivor, and using total hospital charges instead of ICU costs only. In addition, that study had a higher mortality (our 6-month survival was 66% in comparison) and hence less life-years gained.

In the simple sensitivity analysis performed, we found a more pronounced effect of increased mortality than increases in various ICU costs. The overall effect was small, in the magnitude of €57–225 extra per life-year, with no consequences for our main conclusions.

The many different ways of looking at costs make it difficult to draw firm conclusions regarding our findings compared with available data. Our average cost-effectiveness data can only be used as a general guide to the average cost and outcome of intensive care. It is not possible to compare our data with cost-effectiveness ratios from other medical treatments using an incremental cost-effectiveness ratio.

We do, however, believe that the cost of ICU treatment must be studied using the actual expenditure in the ICU, not the hospital charges. Since the QOL changes in the years after ICU treatment, we also find it difficult to calculate QALY using data from one point in time only. We therefore used the unadjusted number of life-years in survivors and calculated the cost for such a year, admitting that these patients as a group have a reduced QOL and also generate additional costs in the years after the ICU stay.

In our opinion, the average cost per life-year gained is not very high in the present study. To put this cost in one perspective: the cost of giving a patient serum lipid-reducing

statins in Norway ranges from € 750 to € 1000 per year for medications only.

It is not an exaggeration to say that the costs of providing intensive care are low when we look at what it actually achieves: the expectations for most survivors after ICU treatment to at least live a 'normal' life regarding further survival.

Competing interests

None declared.

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